THE EFFECT RICE HUSK ASH FILLERS ON PROCESSABILITY OF ABS IMPACT MODIFIED PVC-U.

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Abstract. *Rice husk ash (RHA) fillers were added to ABS impact modified PVC-U in order to reduce cost and maintain or improve properties. Rice husk can also act as reinforcing fillers at certain optimum level of loading. As fusion behavior of filled impact modified PVC-U play a dominant role in the processing operations and in the development of the characteristics processed material due to fusion has a profound influence on mechanical, physical and chemical properties. Based on the literature review, no work has been reported the effect of RHA fillers and the effect of various coupling agents on fusion behavior of PVC-U compound. Thus, a processability study was conducted to investigate the fusion behavior of filled impact modified PVC-U by using Brabender Plasticorder with fitted mixing head. In such cases, here is an attempt to analyze and compare the effect of the RHA loading and various types of coupling agents on the fusion behavior of impact modified PVC-U. Work was carried out on the pre-prepared RHA, with different loading level. Analysis of the results showed that 10 phr RHA filled impact modified PVC-U samples has shorter fusion time and higher fusion torque compared the other level of filler loading. Zirconate treated samples showed longer fusion time and lower processing torque compared to the other types of coupling agents. The experimental results also relate that the low loading of the filler the faster fusion during processing.*

Keywords: *PVC-U, Brabender Plasticorder, Fusion; Rice Husk Ash*

1. Introduction

The development of mechanical properties in PVC products depends critically on the achievement of an adequate level of fusion of the PVC granules during processing. Fusion of PVC has been found to depend on the thermal history, pressure, and shear experienced by the polymer during processing. Assessment of the state of gelation is of utmost importance, but to date, there is no satisfactory, simple method for this measurement. For the past few years a number of methods have become available for the assessment of PVC fusion or gelation[1-10] in PVC products. The effect of lubricants on fusion has also been examined quite extensively, but most work has been concerned with the process of fusion, rather than the state of fusion in the final product. Poly (vinyl chloride) could be referred to as the polymer of many additives for additives. In this case, these additives also can affect the level of fusion. Fusion can be defined as the transition from particular resins granules to melt flow occurs. This process whereby the PVC agglomerates, primary particles, domain and micro domains are attached together during processing is referred to as gelation in Europe and fusion in the United States[11]. In earlier study, to obtain optimum mechanical properties an appropriate level of fusion is needed. Benjamin[12] and Marshall[13] have shown the effect of fusion level on pipe properties. Benjamin found that the long term properties are very dependent on fusion level, like pipe. The time to ductile/brittle transition is depending on fusion level, increasing with increased fusion. Meanwhile, Marshall reported that well-fused samples can fail in a brittle manner form very small flows.

Because of the degree o fusion of PVC compounds gave a profound influence on mechanical, physical and chemical properties, various methods for assessment of fusion have been developed. In this project, Brabender Plasticorder mixing chamber is use to study the fusion behavior of PVC compound. The brabender palsticorder is a torque measuring rheometer to which can be interchangeably attached a number of different measuring heads. Because of its flexibility in shear rates and reasonably good temperature control, the Plasticorder in uniquely suited to investigate the fusion behavior of PVC. The use of Brabender Plasticorder also has proven itself an invaluable tool in the attempt to predict process ability performance before committing large amounts of time and materials.

2. Materials

9 samples was tested, 4 samples of PVC compounds were added with different level of filler RHA loading and another 4 samples of PVC compounds were tested with the different types of coupling agents. In this project, RHA is varied form 10, 20, 30 & 40phr. The coupling agents used was titanate; LICA 12 & LICA 38, Silane 9234 and zirconate; NZ 44. The other sample was kept as reference. Since the objective of this project is to compare the fusion behavior of PVC compounds with different level of RHA loading and various coupling agents, the suggested blend formulation as below;

Blend Formulation 1

To compare the effects of RHA level of loading on PVC fusion behavior by using Brabender Palsticorder at fixed 8 phr ABS impact modifiers.

No. sample	S1	S2	S3	S4
Filler (phr)	10	20	30	40

Blend Formulation 2

To compare the effect of various type of coupling agents at fixed 20 phr RHA.

No. sample	S1	S2	S3	S4
Coupling Agents	LICA 12	LICA 38	Silane 9234	NZ 44

3. Brabender Plasticorder Procedure

The PVC compound was placed into the mixing chamber as a dry powder blend[14]. Each sample weight is 56g to ensure good exposure of the composition to air during mixing, thus the cavity should not be filled completely[15]. All the samples were run at mixer temperature 185 °C with rotor speed 30 rpm. The rotor speed and the temperature are the principle variables and these values should be selected in the light of the purpose of the test. A 5 kg loading chute is used to introduce the powder blend into into the mixer as quickly as possible (within 20s) for best reproducibility and comparability of test result [15]. The sample in the mixing chamber will pass through all stages of fusion. This fusion behavior is studied by observing the curve torques changes.

4. Results and Discussion

The effect of RHA content upon fusion time, fusion torque and end torque were studied on impact modified PVC-U samples. The RHA content ranges from 10, 20, 30, and 40 phr. The content of impact modifier was fixed at 8 phr as used throughout the study. Figure 1shows that as the RHA loading increased the fusion time increased. It is also observed that, the value of fusion torque gradually decreases as the RHA loading increases from 10 to 40 phr. It is observed that shorter the fusion time higher the fusion torque as shown in Figure 1.

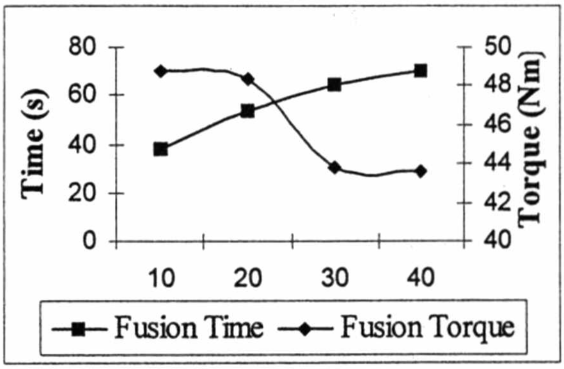

Figure 1: Effect of RHA Content on Fusion Time and Fusion Torque of Impact-Modified PVC-U.

Many researchers have reported that fusion process is more likely to happen in a viscous material in which the shear between particles is high enough [16]. Fusion point is related to disappearance of primary particles [17].

Yee Joon Wee [18] reported that the fusion time for the 0.8μm PCC filled impact-modified PVC-U is shortest followed by GCC 1μm, 3μm, 6μm, and 10μm. Another study conducted by Omya Inc shows that the melt viscosity for PVC compound increases by decreasing calcium carbonate particle size and content [16]. It is believed that finer particle size of filler content provides more particles per unit volume and therefore smoother surfaces and more uniform properties, thus it is able to form more powerful and viscous material so that primarily particles of impact-modified PVC-U to fuse together easily compared to coarsest particles and higher filler loading.

At lower filler loading, then tendency of agglomeration decreased and increases the tendency to fuse faster. Since the lower filler content filled modified PVC-U sample tend to produce higher viscosity melt, it can be reasoned that more force is needed to be consumed in order for the compound to fuse together.

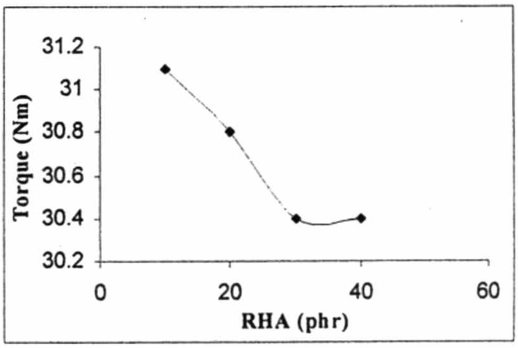

Figure 2: Effect of RHA Content in End Torque of Impact Modified PVC-U.

It was also observed, that the values of the end torque decreased from impact modified PVC-U samples containing RHA from 10 to 40 phr as shown in Figure 2. These results were in agreement with the study by Yee Joon Wee [18] who proposed the end torque decreased as the filler particle increased. Many researchers had reported that end torque values are proportional to melt viscosity of the sample[19]. Reductions of the end torque means reducing in melt viscosity, which less force is required to continue mixing and homogenizing the fused stock.

The larger particle size and higher loading of filler in impact modified PVC-U; require less energy to disperse [20]. The driving forces are minimal; the aggregates that do form are generally weak. Very high surface area types are the most difficult because penetration of the dispersing liquid into the very narrow pores of the agglomerates requires a very efficient dispersant and considerable mechanical work [21]. Besides that the higher loading of RHA has the lower tension with the dispersion is most easily to occur, less force is needed to homogenize the fused [21].

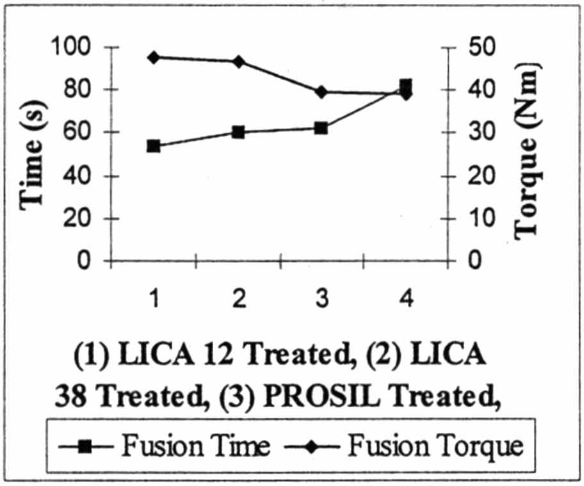

Figure 3: Effect of Coupling Agents on Fusion Time and Fusion Torque of Filled Impact Modified PVC-U.

A comparison between four types of coupling agents namely LICA12, LICA 38, PROSIL 9234 and NZ 44 was investigated. The RHA content was fixed at 20 phr. The impact modifier of the filled sample was fixed at 8 phr as it was used throughout the studies. Figure 3 shows that, unfilled modified PVC-U (blank) sample has the shortest fusion time value followed by samples treated by LICA 12, LICA 38, PROSIL 9234 and NZ 44. However, the unfilled modified PVC-U sample, exhibits the highest fusion torque compared to other samples. Another finding by Tapper [22] who proposed that the addition of filler increases the melt viscosity, but the increase can be reduced by use of a surface treatment such as 1% stearic acid on filler in rigid PVC. He proposed that certain titanates are claimed to be more effective than stearic acid at filler higher above 60 phr based on equilibrium torque determined with a torque rheometer. Ferringo and Wickson [21] revealed that every process has its own set of conditions: shear rate; time temperature profile, stabilization, lubricants, etc. Most studies rely on torque rheometer data. Another study conducted by them also found that surface-treated calcium carbonates significantly reduced peak torque and melt viscosity versus untreated calcium carbonate in typical calendered vinyl compound.

Figure 3 shows the effect of coupling agents on fusion characteristics of impact-modified PVC-U samples. The information above seems to be consistent with the present study. As mentioned earlier, shear is a major factor that controls the fusion of PVC. Higher shear between primarily particles will results in a more viscous material, which more prone to fused the primarily particles together. This will increase the fusion torque consequently. The present results indicate that unfilled samples tend to have shorter fusion time with longer fusion torque compared to filled sample. By adding a coupling agent, the fusion torque dropped even dramatically with much longer fusion time. It is interesting to observe that LICA 12 exhibits the highest fusion torque followed by LICA 38, PROSIL 9234 and NZ 44. This is probably due to the better dispersion and adhesion of surface treated RHA in the PVC-U matrix.

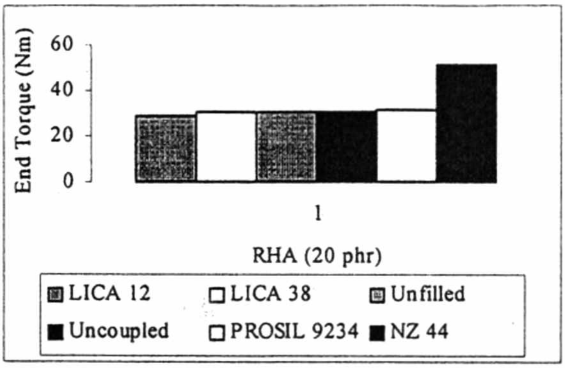

Figure 4: Effect of Coupling Agents on End Torque of Filled Impact-Modified PVC-U Samples.

Figure 4 indicates that, addition 20 phr of RHA increased the end torque value compared to unfilled sample, while it decreases when the filled RHA treated with LICA 12 and LICA 38. It is observed that, PROSIL 9234 and NZ 44 were found not to be effective as it increased the end torque.

The presence of a monomolecular layer of a surface coating such as fatty acid satisfies some of the surface energetic, resulting in soft agglomerates that are easier to break down by the low-level mechanical energy [19]. Therefore surface treated RHA tend to cause the reduction in torque.

Conclusion

The processibility study using brabender plasticorder found that as the RHA loading increases the fusion time increases. It is also revealed that the samples with shorter fusion time higher have higher fusion torque. Upon the addition of 20 phr RHA, the end torque value decreased compared to unfilled sample. The end torque however reduces when the filled RHA being treated with LICA 12 and LICA 38.

Acknowledgements

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